

## **SPIRAL ROLLED LAMINATED BUSHING**

### **BACKGROUND OF THE INVENTION**

[1] This invention relates to a resilient joint bushing for use in joining two structural members.

[2] Typically, a bushing is used to connect two structural members that move relative to one another. Normally, bushings include an inner sleeve of a predetermined diameter secured to one of the structural members and an outer sleeve having a diameter larger than the inner sleeve. In one type of bushing, the inner sleeve is suspended within the outer sleeve in a concentric manner by a resilient and deformable material. The deformable material is typically bonded to both the inner and outer sleeves. The deformable material disposed between the inner and outer sleeves allows a discrete amount of movement. The movement between inner and outer sleeves may be longitudinal or rotational. Such bushings dampen the transmission of vibrations from one structural member to another reducing noise created by such vibrations. This type of bushing does not direct motion between the structural parts.

[3] One other type of bushing is a laminated bushing. Sheets of metal and deformable material are layered to form this type of bushing. The laminated bushing can have greater strength and durability properties than the above-mentioned bushing. Further, laminated bushings may be constructed in a manner that can aid in the direction of movement between structural members. This is accomplished by layering the alternating metal sheets to provide for shear in only desired directions. Laminated bushings however are costly in comparison to typical bushings.

[4] For these reasons, it is desirable to develop a low cost laminated bushing to provide additional strength and durability while providing a cost efficient alternative to conventional bushings.

### SUMMARY OF THE INVENTION

[5] One disclosed embodiment of this invention is a laminated bushing formed by spirally winding a metal sheet with a resilient material to provide a range of motion proportional to an applied force.

[6] The laminated bushing includes a metal sheet spirally wound about a first longitudinal axis forming a spirally shaped cavity. A deformable resilient material such as rubber is disposed on one side of the metal sheet and within the cavity. The metal sheet forming the spiral shaped cavity may mechanically compress the resilient material disposed within the cavities. Alternatively, the resilient material can be vulcanized once within the laminated bushing is formed. The spirally wound laminated bushing includes inner and outer sleeves concentric about the longitudinal axis and that move relative to one another in direct proportion to the material deformation properties of the resilient material disposed between the metal sheet. However, because the resilient material is alternatively layered with the metal sheet the direction of movement between the inner sleeve and the outer sleeve is controlled by the specific configuration of the laminated bushing.

[7] The configuration of the laminated bushing can be adapted to provide various directions of movement between two fastened structural members. In one embodiment, the inner sleeve is concentric with the outer sleeve. The outer sleeve forms a continuous cylinder and movement of the inner sleeve relative to the outer sleeves can occur in many planes.

[8] In another embodiment, the laminated bushing includes a plurality of grooves disposed annularly about the longitudinal axis. Movement of the resilient material is resisted at a greater rate in a direction across or perpendicular to the grooves. In this way the grooves can be configured to direct motion between the two structural members by increasing resistance to movement across the grooves. Further embodiments include grooves that are disposed along the longitudinal axis, and grooves that are spirally wound about longitudinal axis.

[9] The invention includes the method of constructing a spirally wound bushing

including the steps of bonding a resilient deformable material to a least one side of a metal sheet, then rolling the metal sheet over itself about a longitudinal axis such that a plurality of spirally wound cavities are formed. The method further includes forming the spirally wound cavities such that the resilient deformable material is compressed within the spiral cavities.

- [10] The laminated bushing of the subject invention provide the benefits of increased strength and durability along with providing a means of directionally controlling movement of a structural member.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

- [11] The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows:

- [12] Figure 1 is a perspective view of a spirally wound laminated bushing;

- [13] Figure 2 is a perspective view of another embodiment of the laminated bushing including annular grooves;

- [14] Figure 3 is a perspective view of another embodiment of the laminated bushing with longitudinal grooves;

- [15] Figure 4, is another embodiment of the laminated bushing including spiral grooves;

- [16] Figure 5 is a perspective view of the spirally wound laminated bushing installed in a leaf spring bracket assembly;

- [17] Figure 6, is a perspective view of another application of the laminated bushing to support a stabilizer bar;

- [18] Figure 7, is a perspective view of another application of the laminated bushing installed in upper and lower control arms of a wheel assembly;

- [19] Figure 8 is a plan view of a laminated bushing used as a hinge mechanism for a door.

- [20] Figure 9A-9D are schematic views of the method steps for fabricating the spirally wound laminated bushing; and
- [21] Figure 10 is a perspective view the method step of cutting a laminated bushing to a required length.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

- [22] Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views and embodiments, a laminated bushing generally indicated at 10 is shown in Figure 1. The laminated bushing 10 includes a metal sheet 12 spirally wound about a longitudinal axis 14 to form a spirally shaped cavity 20. A resilient material 16 such as rubber is disposed between the metal sheet 12 and within the spiral shaped cavity 20. Preferably, the resilient material 16 is mechanically compressed between the metal sheets 12. Alternatively, the resilient material 16 can be rubber that is vulcanized after formation of the bushing 10. It should be understood that the resilient material 16 could be of any type known in the art. Preferably, the inner sleeve 22 is rotatable relative to an outer sleeve 18 in a proportional manner related to the specific material properties of the resilient material 16. The spirally wound metal sheet 12 is inserted into the outer sleeve 18. The inner sleeve 22 is formed concentric with the outer sleeve 18 about the longitudinal axis 14. The inner sleeve 22 is movable along the longitudinal axis 14 relative to the outer sleeve 18 in a proportional manner dependent on the specific properties of the resilient material 16.
- [23] Referring to Figure 2, another embodiment of the laminated bushing includes a plurality of mechanically formed grooves 24. The grooves 24 are formed at intervals along the axis 14 of the laminated bushing 10. Preferably, the grooves 24 are part of the metal sheet and become an integral part of the laminated bushing throughout the entire spirally wound bushing 10. The grooves 24 direct movement of the inner sleeve 22 relative to the outer sleeve 18 by increasing the resistance to movement in a direction across or perpendicular to the grooves 24. The grooves 24 increase resistance of the resilient material 16 in a direction perpendicular to the grooves 24. In this embodiment,

the grooves 24 are arranged at intervals about the longitudinal axis 14 to increase resistance to movement of the inner sleeve 22 along the longitudinal axis 14 relative to the outer sleeve 18.

[24] Referring to Figure 3, another embodiment including a plurality of grooves 26 is disclosed. In this embodiment, the grooves 26 are positioned longitudinally throughout the entire laminated bushing 10. The grooves are formed within the metal sheet 12 to direct movement of the inner sleeve 22 relative to the outer sleeve 18 by increasing resistance to motion perpendicular to the grooves 26. The longitudinal grooves 26 resist rotational movement of the inner sleeve 22 relative to the outer sleeve 18 thereby encouraging movement along the longitudinal axis 14. Movement along the longitudinal axis 14 would be such that the inner sleeve 22 moves in a telescoping motion relative to the outer sleeve 18.

[25] Referring to Figure 4, another embodiment of the laminated bushing 10 is shown. The laminated bushing includes a plurality of spirally wound grooves 28 within the metal sheet 12 such that the resilient material 16 is directed for both rotational and axial movement. The spirally wound grooves 28 direct the inner sleeve 22 to rotate about the longitudinal axis 14 in proportion to movement along the longitudinal axis 14. The spirally wound grooves 28 direct movement of the inner sleeve 22 relative to the outer sleeve 18 along the longitudinal axis 14 in proportion to rotation about the longitudinal axis 14. In other words, the inner sleeve 22 has a lower resistance to movement in a telescoping, rotational manner relative to the outer sleeve 18.

[26] The laminated bushings 10 enable control of the direction of motion by using alternating layers of metal sheet 12 and resilient material 16 with or without the formed geometry. The embodiments of the laminated bushing described and shown in Figures 1-4 are only examples of various geometric configurations integrally formed to the laminated bushing 10 to control motion of the inner sleeve 22 relative to the outer sleeve 18. It should be understood that it is within the contemplation of this invention that the grooves may be of any configuration known to a worker skilled in the art such that the direction of motion can be controlled dependent on a specific application. The

laminated bushing 10 can be incorporated into any application in which bushings are currently being used such as for joining of various suspension components.

[27] Referring to Figure 5, a leaf spring assembly 44 is shown including the laminated bushings 10 having spirally wound grooves 28. The laminated bushings 10 enable control of the direction of motion to assist in the changing wheel alignment by changing chamber, castor, toe and the like. The laminated bushings 10 are part of the hanger bracket 46 and move proportionally in response to compression of the leaf spring assembly 44. Movement of the leaf spring assembly 44 can be used to direct movement of the leaf spring assembly 44 to adjust over-steer or under-steer. The laminated bushings 10 are arranged such that compression of the leaf spring 44 moves the rear bushing in one direction and moves the front bushing in the opposite direction to provide a pivoting movement of the entire leaf spring assembly 44 as shown by the arrows A.

[28] Referring to Figure 6, in this embodiment the laminated bushings 10 secure mounting brackets 46 for a stabilizer bar 48 to direct and control movement of the stabilizer bar 48 proportionally to an applied force. The stabilizer bar 48 is mounted within the laminated bushings 10 that are in turn mounted to the body of the motor vehicle schematically shown as 47. The ends of the stabilizer bar 50 are attached to a wheel assembly (Not Shown) of the motor vehicle such that during a turn one arm of the stabilizer bar is twisted to transmit a counter rotational force across the vehicle to a side opposite the turn to inhibit roll of the body of the motor vehicle 47. The laminated bushings 10 controls the amount of rotation in proportional response to the applied forces such that a roll rate of the vehicle body 47 is controlled. In this embodiment the laminated bushings 10 can include spirally wound grooves 28 to control linear movement along an axis 51 as well as rotational movement.

[29] Referring to Figure 7, a wheel assembly 52 including upper and lower control arms 54, 56 pivotally attached to a frame member 62 at one end and to a spindle arm 60 opposite the frame member 62. Each pivotal connection 64 includes a laminated bushing 10. The laminated bushings are configured to direct and control relative

movement between the upper, lower, and spindle arms 54,56, and 60 in response to forces applied to each pivotal connection 64 by movement of the wheel assembly 52.

[30] Referring to Figure 8, another embodiment of the laminated bushing 10 is shown as a door hinge 64 to allow directional motion of the door as well as providing a means of holding a door 66 open in various intermediate positions. The laminated bushing 10 is mounted vertically along an axis 14 and includes spirally wound grooves 28. The laminated bushing 10 is mounted to a support 68 such that the weight of a door 66 is exerted downward onto the laminated bushing 10. The spirally wound grooves 28 are disposed on the laminated bushing 10 such that opening of the door 66 moves the inner sleeve 22 upwardly an amount proportional to the amount in which the door 66 is opened or rotated. The weight of the door 66 exerts a force downward on the laminated bushing 10 such that the door 66 will be directed to rotate toward a closed position. The downward force exerted on the laminated bushing 10 causes the door 66 to rotate toward the closed position.

[31] Referring to Figures 9A-9D, the invention also includes a method of forming the laminated bushing 10 including the steps of affixing a resilient material to the metal sheet. The resilient material 16 may be affixed by any means known in the art such as utilizing adhesive or coating a metal sheet 12 with the resilient material 16. The resilient material 16 and metal sheet 12 are in turn spirally wound back about the longitudinal axis 14 to form a spirally shaped cavity 20 with the metal sheet 12 such that the resilient material 16 is disposed within the spirally shaped cavity 20. The spirally wound metal sheet and resilient material 16 is in turn inserted between an inner sleeve 22 and an outer sleeve 18. Alternatively, the metal sheet 12 may be secured back onto itself to form the inner and outer sleeves 22,18 from a common metal sheet 12. Preferably, the inner sleeve 22 is preferably concentric with the outer sleeve 18.

[32] The resilient material 16 is mechanically compressed within the spirally shaped cavity 20 during the winding step to form alternating layers of metal sheet 12 and resilient material 16. Alternatively, the resilient material 16 is composed of rubber and adhered to the metal sheet 12 by a vulcanization process as is known in the art. The

vulcanized resilient material 16 adheres to the metal sheet 12 of the laminated bushing 10.

[33] The method also includes the step of mechanically forming a plurality of grooves within the metal sheet. As discussed hereinabove, the grooves 24 may be of any configuration and extend in any direction. The resilient material is then adhered to the metal sheet 12 and wound to form the spiral cavity 20.

[34] Referring to Figure 10, the method also includes the step of forming a length 72 of laminated bushings 10. The laminated bushing 10 may be formed from a metal sheet having a length 70 longer than that required for a specific application, then cut into smaller required lengths 72.

[35] The foregoing description is exemplary and not just a material specification. The invention has been described in an illustrative manner, and should be understood that the terminology used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present invention are possible in light of the above teachings. The preferred embodiments of this invention have been disclosed, however, one of ordinary skill in the art would recognize that certain modifications are within the scope of this invention. It is understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. For that reason, the following claims should be studied to determine the true scope and content of this invention.

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